

Figure 1A

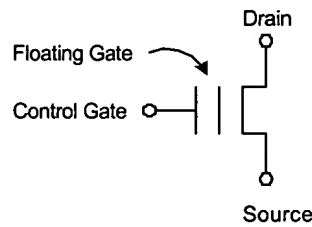


Figure 1B

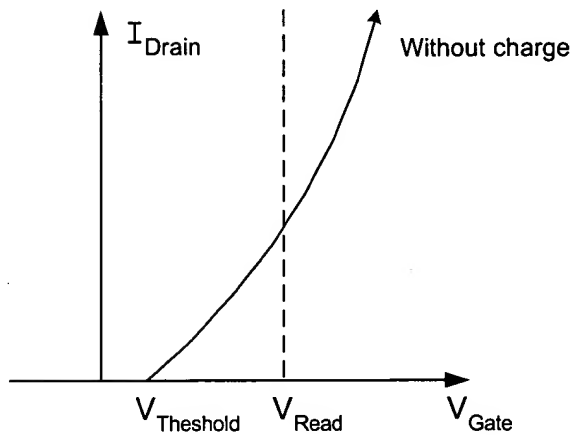


Figure 1C

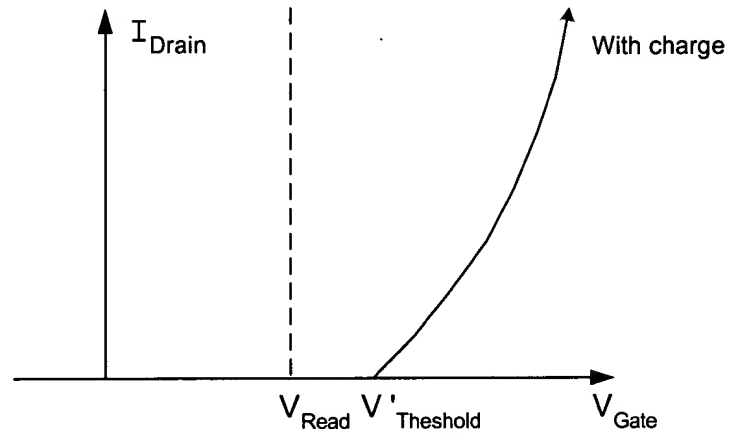


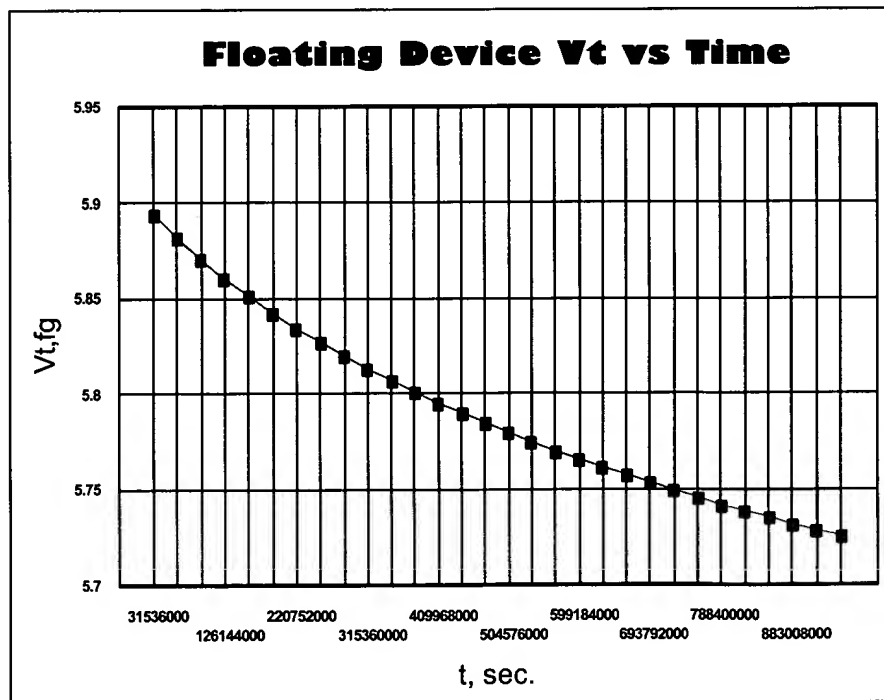
Figure 1D

# Calculation of memory cell retention characteristics

					Seconds	Time Period
q0, C	m0, kg	kb, J/K	h, J-s	hb, J-s	31536000	1 year
1.6022E-019	9.1095E-031	1.38062E-023	6.62617E-034	1.054588E-034	94608000	3 years
					1.89E+008	6 years
b0, eV (barrier)	el	mr, effective mass ratio	T, K degree		2.84E+017	9 years
2.9	3.9	0.5	300		3.78E+008	12 years
					4.73E+008	15 years
C	b				9.08E+009	18 years
1.0630E-006	2.3854E+008				6.62E+008	21 years
					7.57E+008	24 years
					8.51E+008	27 years
					9.46E+008	30 years

Lfg um	0.6000	Channel length of floating gate device
Wfg um	1000.0000	Channel width of floating gate device.
Hfg um	0.0900	Thickness of floating gate polysilicon conductor
Wrx um	0.5000	Width of floating gate overlapping shallow trench isolation
Ttunox A	80	Tunnel oxide thickness
Tono A	190	Thickness of Oxide-Nitride-Oxide dielectric between floating gate and control gate for capacitive coupling
Tswox A	300	Thickness of sidewall oxide between floating gate and control gate for sidewall coupling
Xfd um	0.0500	Length of floating gate overlapping drain region of the floating gate MOSFET
Xfs um	0.3500	Length of floating gate overlapping source region of the floating gate MOSFET
Ainj um2	0.0438	Area of the electron tunneling region between the floating gate and the source for resetting the floating gate charge
Cfc fF	1089.5358	Capacitance between the floating gate and the control gate
Cfsx fF	0.4313	Capacitance between the floating gate and the silicon substrate
Cfd fF	0.1078	Capacitance between the floating gate and the drain
Cfs fF	0.7547	Capacitance between the floating gate and the source
Cfg fF	1090.8295	Total floating gate capacitance
Cr,wl	0.9988	Control gate to floating gate coupling ratio
Cr,src	0.0007	Source junction to floating gate coupling ratio
Vt,fg V	0.90	Threshold voltage of floating gate MOSFET
Verase	0.00	Erase voltage applied to the source(not used here, set to zero)
Vg,ini	-5.00	Initial floating charged voltage
Va	0.00	Actual erase volatge (equal to applied + charge stored on the floating)
S	3.76E+016	Derived parameter in the floating gate "erase" equation
X	1.27E+011	Derived parameter in the floating gate "erase" equation

t, sec.	Vt,fg
0.00001	5.907
31536000	5.894
63072000	5.882
94608000	5.871
1.26E+008	5.861
1.58E+008	5.852
1.89E+008	5.843
2.21E+008	5.835
2.52E+008	5.827
2.84E+008	5.820
3.15E+008	5.814
3.47E+008	5.807
3.78E+008	5.801
4.1E+008	5.795
4.42E+008	5.790
4.73E+008	5.785
5.05E+008	5.780
5.36E+008	5.775
5.68E+008	5.770
5.99E+008	5.766
6.31E+008	5.762
6.62E+008	5.757
6.94E+008	5.753
7.25E+008	5.750
7.57E+008	5.746
7.88E+008	5.742
8.2E+008	5.739
8.51E+008	5.735
8.83E+008	5.732
9.15E+008	5.729
9.46E+008	5.726



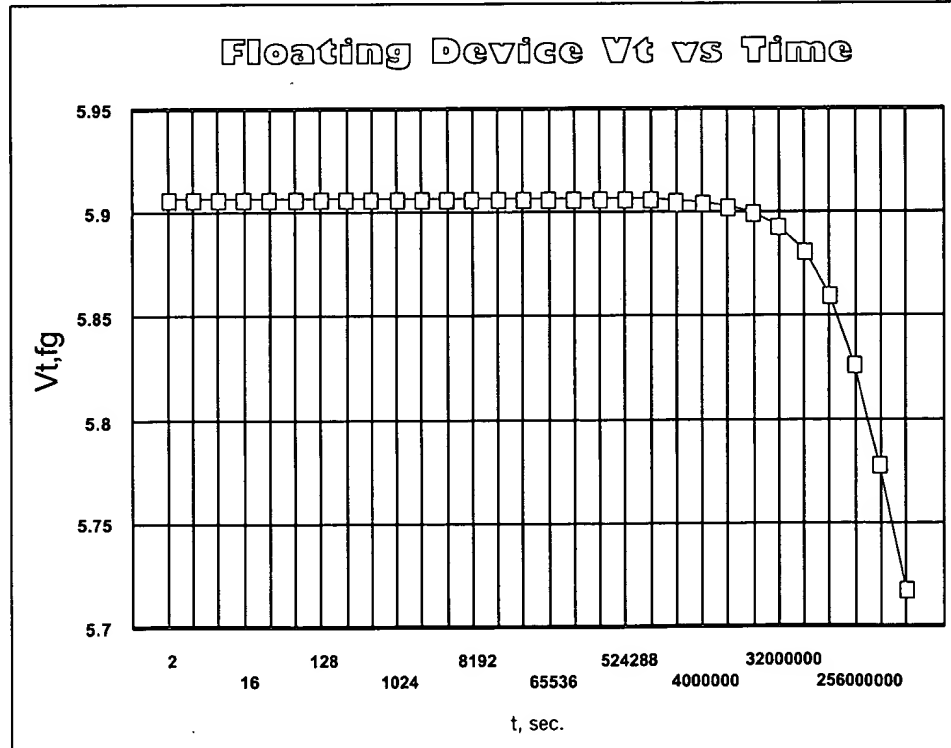
Figures 1E-1F

# Calculation of memory cell retention characteristics

					Seconds	Time Period
q0, C	m0, kg	kb, J/K	h, J-s	hb, J-s	60	1 minute
1.6022E-019	9.1095E-031	1.38062E-023	6.62617E-034	.....	3600	1 hour
					86400	1 day
b0, eV (barrier) e1	mr, effective mass ratio		T, K degree		604800	1 week
2.9	3.9	0.5	300		2592000	1 month
					.....	1 year
C	b				.....	4 years
1.0630E-006	2.3854E+008				.....	16 years
					.....	32 years

Lfg um	0.6000	Channel length of floating gate device
Wfg um	1000.0000	Channel width of floating gate device.
Hfg um	0.0900	Thickness of floating gate polysilicon conductor
Wrx um	0.5000	Width of floating gate overlapping shallow trench isolation
Ttunox A	80	Tunnel oxide thickness
Tono A	190	Thickness of Oxide-Nitride-Oxide dielectric between floating gate and control gate for capacitive coupling
Tswox A	300	Thickness of sidewall oxide between floating gate and control gate for sidewall coupling
Xfd um	0.0500	Length of floating gate overlapping drain region of the floating gate MOSFET
Xfs um	0.3500	Length of floating gate overlapping source region of the floating gate MOSFET
Ainj um2	0.0438	Area of the electron tunneling region between the floating gate and the source for resetting the floating gate charge
Cfc fF	1089.5358	Capacitance between the floating gate and the control gate
Cfsx fF	0.4313	Capacitance between the floating gate and the silicon substrate
Cfd fF	0.1078	Capacitance between the floating gate and the drain
Cfs fF	0.7547	Capacitance between the floating gate and the source
Cfg fF	1090.8295	Total floating gate capacitance
Gr, wl	0.9988	Control gate to floating gate coupling ratio
Gr, src	0.0007	Source junction to floating gate coupling ratio
Vt, fg V	0.90	Threshold voltage of floating gate MOSFET
Verase	0.00	Erase voltage applied to the source(not used here, set to zero)
Vfg, ini	-5.00	Initial floating charged voltage
Va	0.00	Actual erase volatge (equal to applied + charge stored on the floating)
S	3.76E+016	Derived parameter in the floating gate "erase" equation
X	1.27E+011	Derived parameter in the floating gate "erase" equation

t, sec.	Vt, fg
0.00001	5.907
2	5.907
4	5.907
8	5.907
16	5.907
32	5.907
64	5.907
128	5.907
256	5.907
512	5.907
1024	5.907
2048	5.907
4096	5.907
8192	5.907
16384	5.907
32768	5.907
65536	5.907
131072	5.907
262144	5.907
524288	5.907
1000000	5.907
2000000	5.906
4000000	5.905
8000000	5.904
16000000	5.900
32000000	5.894
64000000	5.881
.....	5.860
.....	5.827
.....	5.779
.....	5.718



Figures 1G-1H

# Calculation of nV memory cell retention characteristics

q0, C 1.6022E-019 m0, kg 9.1095E-031 kb, J/K 1.38062E-023 h, J-s 6.62617E-034 hb, J-s .....

b0, eV (barrier) 2.9 mr, effective mass ratio 3.9 T, K degree 300

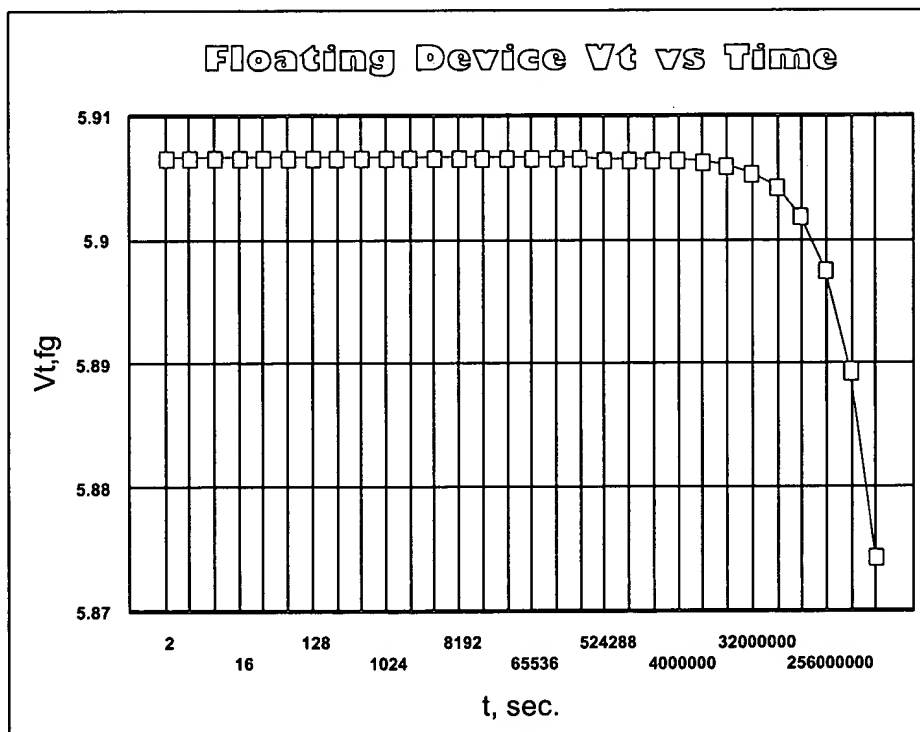
C 1.0630E-006 b 2.3854E+008

Seconds Time Period

60 1 minute  
3600 1 hour  
86400 1 day  
604800 1 week  
2592000 1 month  
..... 1 year  
..... 4 years  
..... 16 years  
..... 32 years

Lfg um 0.6000 Channel length of floating gate device  
Wfg um 1000.0000 Channel width of floating gate device.  
Hfg um 0.0900 Thickness of floating gate polysilicon conductor  
Wrj um 0.5000 Width of floating gate overlapping shallow trench isolation  
Ttunox A 85 Tunnel oxide thickness  
Tono A 190 Thickness of Oxide-Nitride-Oxide dielectric between floating gate and control gate for capacitive coupling  
Tswox A 300 Thickness of sidewall oxide between floating gate and control gate for sidewall coupling  
Xfd um 0.0500 Length of floating gate overlapping drain region of the floating gate MOSFET  
Xfs um 0.3500 Length of floating gate overlapping source region of the floating gate MOSFET  
Ainj um2 0.0438 Area of the electron tunneling region between the floating gate and the source for resetting the floating gate c  
Cfc fF 1089.5358 Capacitance between the floating gate and the control gate  
Cfsx fF 0.4059 Capacitance between the floating gate and the silicon substrate  
Cfd fF 0.1015 Capacitance between the floating gate and the drain  
Cfs fF 0.7103 Capacitance between the floating gate and the source  
Cfg fF 1090.7534 Total floating gate capacitance  
Cr,gl 0.9989 Control gate to floating gate coupling ratio  
Cr,src 0.0007 Source junction to floating gate coupling ratio  
Vt,fg V 0.90 Threshold voltage of floating gate MOSFET  
Verase 0.00 Erase voltage applied to the source(not used here, set to zero)  
Vfg,ini -5.00 Initial floating charged voltage  
Va 0.00 Actual erase volatge (equal to applied + charge stored on the floating)  
4.09E+017 Derived parameter in the floating gate "erase" equation  
1.20E+011 Derived parameter in the floating gate "erase" equation

t, sec. Vt,fg  
0.00001 5.907  
2 5.907  
4 5.907  
8 5.907  
16 5.907  
32 5.907  
64 5.907  
128 5.907  
256 5.907  
512 5.907  
1024 5.907  
2048 5.907  
4096 5.907  
8192 5.907  
16384 5.907  
32768 5.907  
65536 5.907  
131072 5.907  
262144 5.907  
524288 5.907  
1000000 5.907  
2000000 5.907  
4000000 5.906  
8000000 5.906  
1.6E+007 5.906  
3.2E+007 5.905  
6.4E+007 5.904  
..... 5.902  
..... 5.898  
..... 5.889  
..... 5.874



Figures 1I-1J

Increasing time  
Decreasing floating gate charge

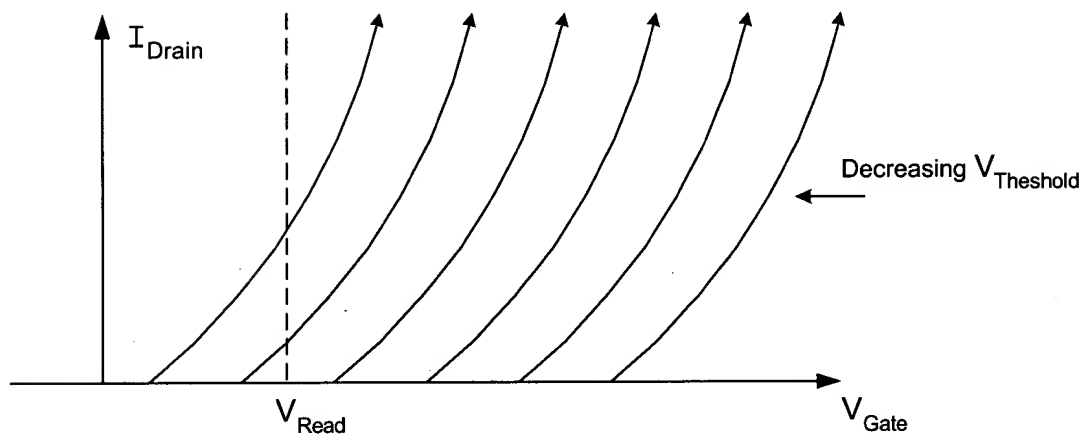
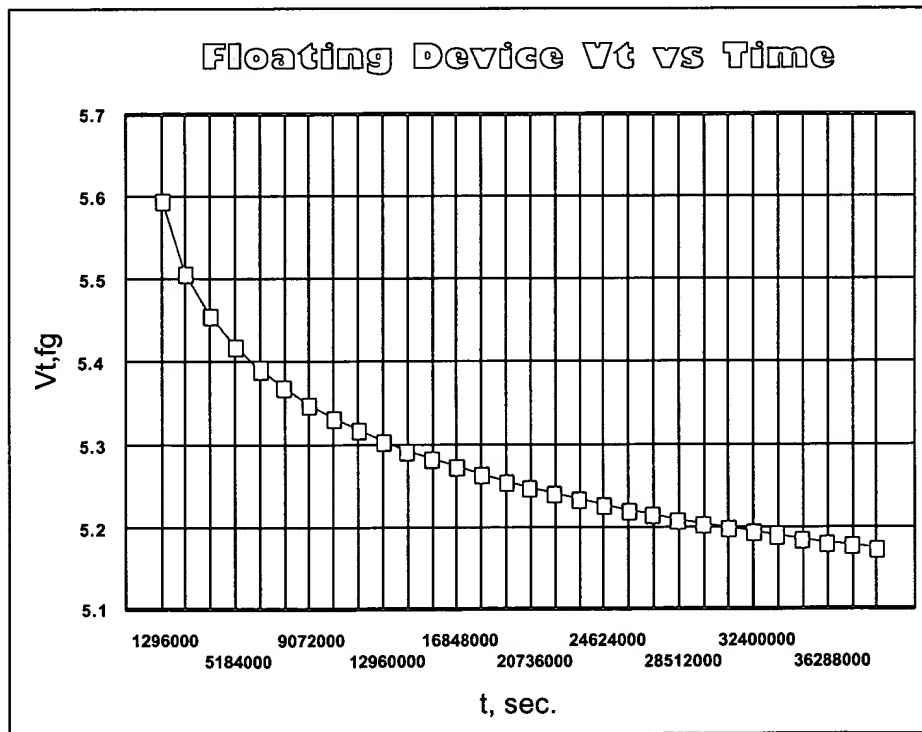


Figure 1K

# Calculation of time cell retention characteristics

					Seconds	Time Period
q0, C	m0, kg	kb, J/K	h, J-s	hb, J-s	2592000	1 month
1.6022E-019	9.1095E-031	1.38062E-023	6.62617E-034	*****	5184000	2 months
					7776000	3 months
b0, eV (barrier)εl	mr, effective mass ratio	T, K degree			*****	4 months
2.9	3.9	0.5	300		*****	5 months
C	b				*****	6 months
1.0630E-006	2.3854E+008				*****	7 months
					*****	8 months
					*****	9 months
					*****	10 months
					*****	11 months
					*****	12 months
Lfg um	0.6000	Channel length of floating gate device			*****	13 months
Wfg um	1000.0000	Channel width of floating gate device.			*****	14 months
Hfg um	0.0900	Thickness of floating gate polysilicon conductor			*****	15 months
Wrx um	0.5000	Width of floating gate overlapping shallow trench isolation			*****	16 months
Ttunox A	65	Tunnel oxide thickness				
Tono A	190	Thickness of Oxide-Nitride-Oxide dielectric between floating gate and control gate for capacitive coupling				
Tswox A	300	Thickness of sidewall oxide between floating gate and control gate for sidewall coupling				
Xfd um	0.0500	Length of floating gate overlapping drain region of the floating gate MOSFET				
Xfs um	0.3500	Length of floating gate overlapping source region of the floating gate MOSFET				
Ainj um2	0.0438	Area of the electron tunneling region between the floating gate and the source for resetting the floating gate charge				
Cfc fF	1089.5358	Capacitance between the floating gate and the control gate				
Cfsx fF	0.5308	Capacitance between the floating gate and the silicon substrate				
Cfd fF	0.1327	Capacitance between the floating gate and the drain				
Cfs fF	0.9288	Capacitance between the floating gate and the source				
Cfg fF	1091.1281	Total floating gate capacitance				
Cfw	0.9985	Control gate to floating gate coupling ratio				
Csrc	0.0009	Source junction to floating gate coupling ratio				
Vtfg V	0.90	Threshold voltage of floating gate MOSFET				
Verase	0.00	Erase voltage applied to the source(not used here, set to zero)				
Vfg,ini	-5.00	Initial floating charged voltage				
Va	0.00	Actual erase volatge (equal to applied + charge stored on the floating)				
S	2.93E+013	Derived parameter in the floating gate "erase" equation				
X	1.56E+011	Derived parameter in the floating gate "erase" equation				

t, sec.	Vt,fg
0.00001	5.909
1296000	5.596
2592000	5.508
3888000	5.456
5184000	5.420
6480000	5.392
7776000	5.369
9072000	5.349
*****	5.333
*****	5.318
1.3E+007	5.305
*****	5.293
*****	5.283
*****	5.273
*****	5.264
*****	5.256
*****	5.248
2.2E+007	5.240
*****	5.234
*****	5.227
*****	5.221
*****	5.215
*****	5.210
*****	5.204
*****	5.199
*****	5.195
*****	5.190
3.5E+007	5.185
*****	5.181
*****	5.177
*****	5.173



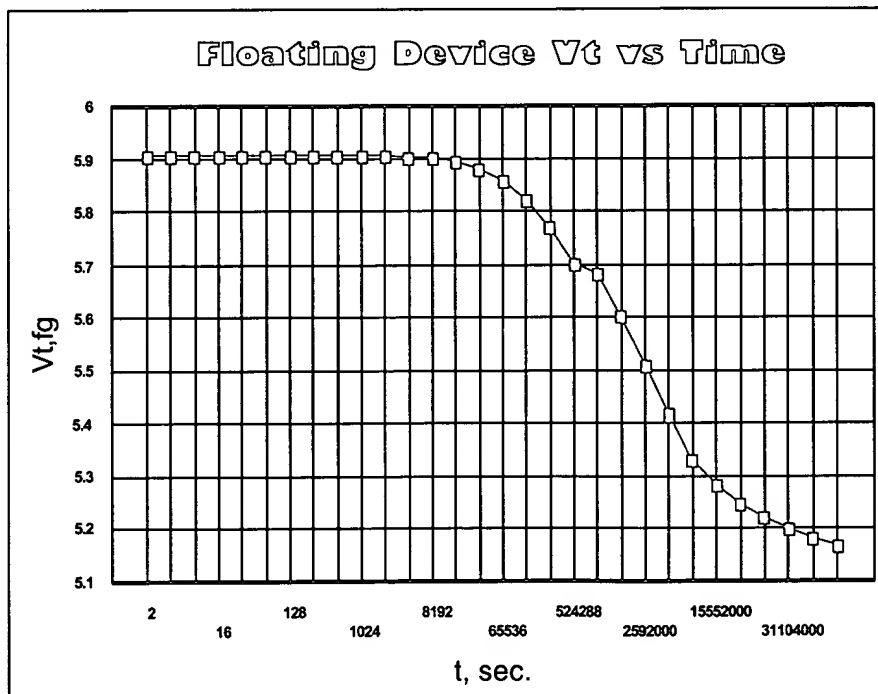
Figures 1L-1M

# Calculation of time cell retention characteristics

					Seconds	Time Periods
q0, C	m0, kg	kb, J/K	h, J-s	hb, J-s	60	1 minute
1.6022E-019	9.1095E-031	1.38062E-023	6.62617E-034	1.054588E-034	3600	1 hour
					86400	1 day
b0, eV (barrier)	$\epsilon_l$	mr, effective mass ratio	T, K degree		604800	1 week
2.9	3.9	0.5	300		1209600	2 weeks
					2592000	1 month
C	b				5184000	2 months
1.0630E-006	2.3854E+008				10368000	4 months
					15552000	6 months
					20736000	8 months
					25920000	10 months
					31104000	12 months
					36288000	14 months
					41472000	16 months

Lfg um	0.6000	Channel length of floating gate device
Wfg um	1000.0000	Channel width of floating gate device.
Hfg um	0.0900	Thickness of floating gate polysilicon conductor
Wrux um	0.5000	Width of floating gate overlapping shallow trench isolation
Ttunox A	65	Tunnel oxide thickness
Tono A	190	Thickness of Oxide-Nitride-Oxide dielectric between floating gate and control gate for capacitive coupling
Tswox A	300	Thickness of sidewall oxide between floating gate and control gate for sidewall coupling
Xfd um	0.0500	Length of floating gate overlapping drain region of the floating gate MOSFET
Xfs um	0.3500	Length of floating gate overlapping source region of the floating gate MOSFET
Ainj um <sup>2</sup>	0.0438	Area of the electron tunneling region between the floating gate and the source for resetting the floating gate charge
Cfc fF	1089.5358	Capacitance between the floating gate and the control gate
Cfsx fF	0.5308	Capacitance between the floating gate and the silicon substrate
Cfd fF	0.1327	Capacitance between the floating gate and the drain
Cfs fF	0.9288	Capacitance between the floating gate and the source
Cfg fF	1091.1281	Total floating gate capacitance
Crwl	0.9985	Control gate to floating gate coupling ratio
Gsrc	0.0009	Source junction to floating gate coupling ratio
Vtfg V	0.90	Threshold voltage of floating gate MOSFET
Verase	0.00	Erase voltage applied to the source(not used here, set to zero)
Vfg,ini	-5.00	Initial floating charged voltage
Va	0.00	Actual erase voltage (equal to applied + charge stored on the floating)
S	2.93E+013	Derived parameter in the floating gate "erase" equation
X	1.56E+011	Derived parameter in the floating gate "erase" equation

t, sec.	Vt,fg
0.00001	5.909
2	5.909
4	5.909
8	5.909
16	5.909
32	5.909
64	5.909
128	5.909
256	5.908
512	5.908
1024	5.908
2048	5.907
4096	5.905
8192	5.902
16384	5.895
32768	5.883
65536	5.861
131072	5.824
262144	5.771
524288	5.702
1048576	5.686
2097152	5.604
4194304	5.508
8388608	5.420
16777216	5.333
33554432	5.283
67108864	5.248
134217728	5.221
268435456	5.199
536870912	5.181
1073741824	5.166



Figures 1N-1O

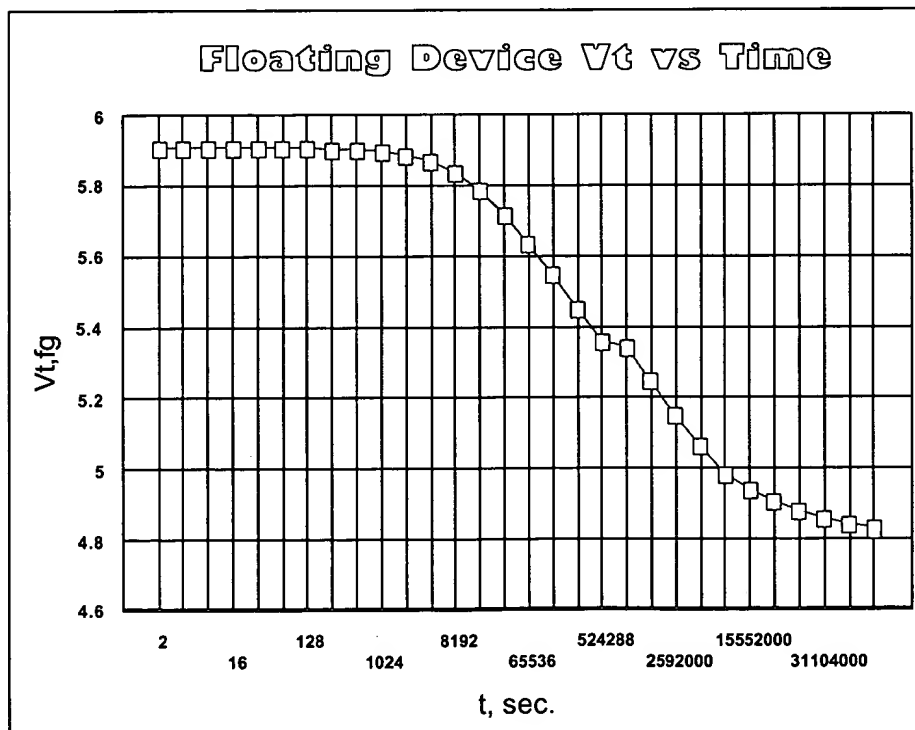
7/22  
AUS9-1999-0269-US1

# Calculation of time cell retention characteristics

					Seconds	Time Period
q0, C	m0, kg	kb, J/K	h, J-s	hb, J-s	60	1 minute
1.6022E-019	9.1095E-031	1.38062E-023	6.62617E-034	.....	3600	1 hour
					86400	1 day
b0, eV (barrier) $\epsilon_l$	mr, effective mass ratio		T, K degree		604800	1 week
2.9	3.9	0.5	300		1209600	2 weeks
					2592000	1 month
C	b				5184000	2 months
1.0630E-006	2.3854E+008				.....	4 months
					.....	6 months
					.....	8 months
					.....	10 months
					.....	12 months
					.....	14 months
					.....	16 months

Lfg um	0.6000	Channel length of floating gate device
Wfg um	1000.0000	Channel width of floating gate device.
Hfg um	0.0900	Thickness of floating gate polysilicon conductor
Wrx um	0.5000	Width of floating gate overlapping shallow trench isolation
Ttunox A	60	Tunnel oxide thickness
Tono A	190	Thickness of Oxide-Nitride-Oxide dielectric between floating gate and control gate for capacitive coupling
Tswox A	300	Thickness of sidewall oxide between floating gate and control gate for sidewall coupling
Xfd um	0.0500	Length of floating gate overlapping drain region of the floating gate MOSFET
Xfs um	0.3500	Length of floating gate overlapping source region of the floating gate MOSFET
Ainj um <sup>2</sup>	0.0438	Area of the electron tunneling region between the floating gate and the source for resetting the floating gate charge
Cfc fF	1089.5358	Capacitance between the floating gate and the control gate
Cfsx fF	0.5750	Capacitance between the floating gate and the silicon substrate
Cfd fF	0.1438	Capacitance between the floating gate and the drain
Cfs fF	1.0063	Capacitance between the floating gate and the source
Cfg fF	1091.2608	Total floating gate capacitance
Caw	0.9984	Control gate to floating gate coupling ratio
Csrc	0.0009	Source junction to floating gate coupling ratio
Vtfg V	0.90	Threshold voltage of floating gate MOSFET
Verase	0.00	Erase voltage applied to the source(not used here, set to zero)
Vfg,ini	-5.00	Initial floating charged voltage
Va	0.00	Actual erase volatge (equal to applied + charge stored on the floating)
X	2.70E+012	Derived parameter in the floating gate "erase" equation
	1.69E+011	Derived parameter in the floating gate "erase" equation

t, sec.	Vt, fg
0.00001	5.909
2	5.909
4	5.909
8	5.909
16	5.909
32	5.909
64	5.909
128	5.908
256	5.907
512	5.904
1024	5.898
2048	5.888
4096	5.870
8192	5.838
16384	5.789
32768	5.721
65536	5.639
131072	5.549
262144	5.455
524288	5.360
1048576	5.341
2097152	5.250
4194304	5.152
8388608	5.067
16777216	4.985
33554432	4.938
67108864	4.906
134217728	4.881
268435456	4.861
536870912	4.844
1073741824	4.830



Figures 1P-1Q



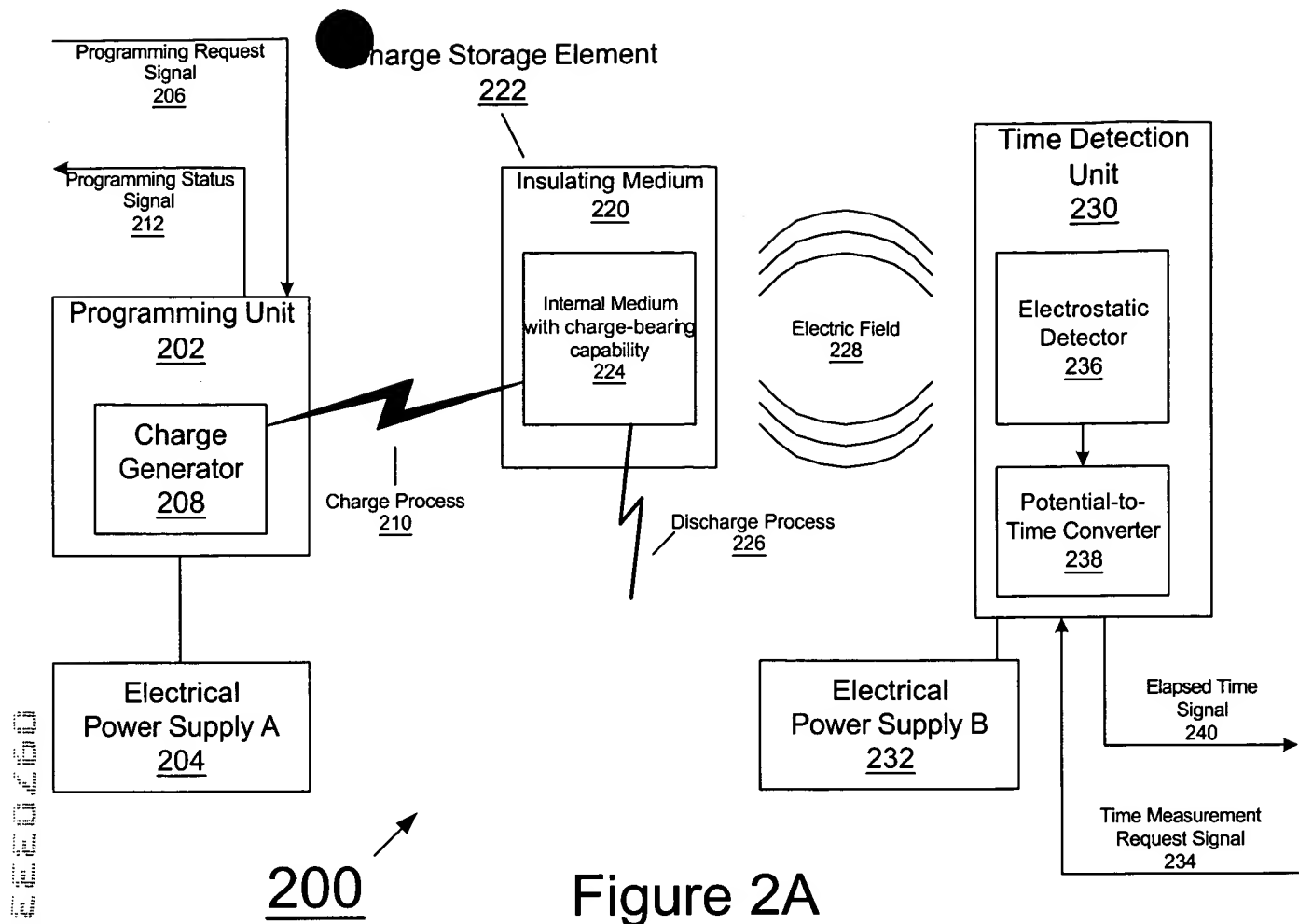


Figure 2A

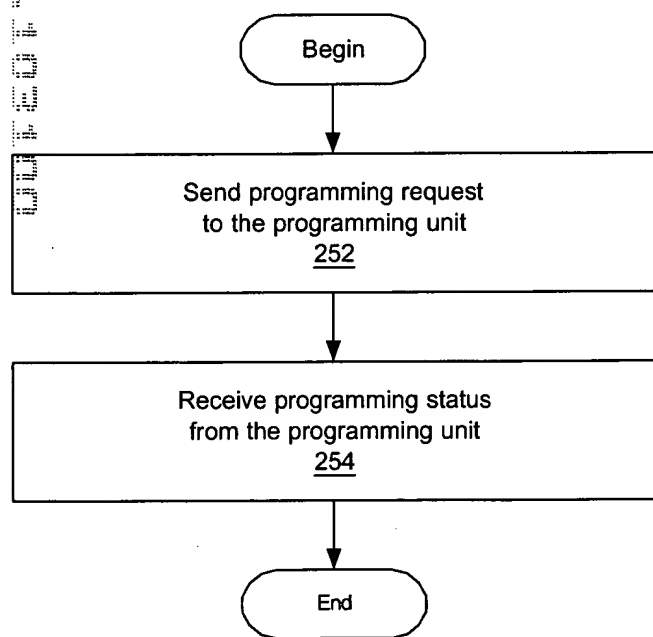


Figure 2B

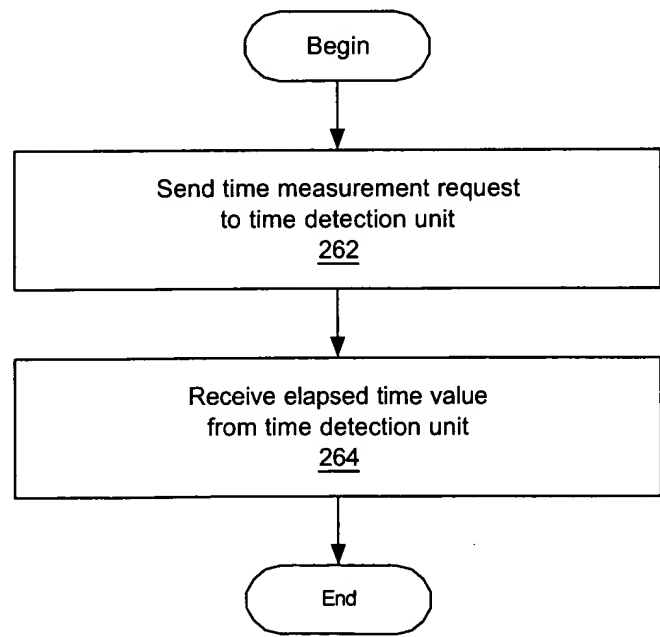


Figure 2C

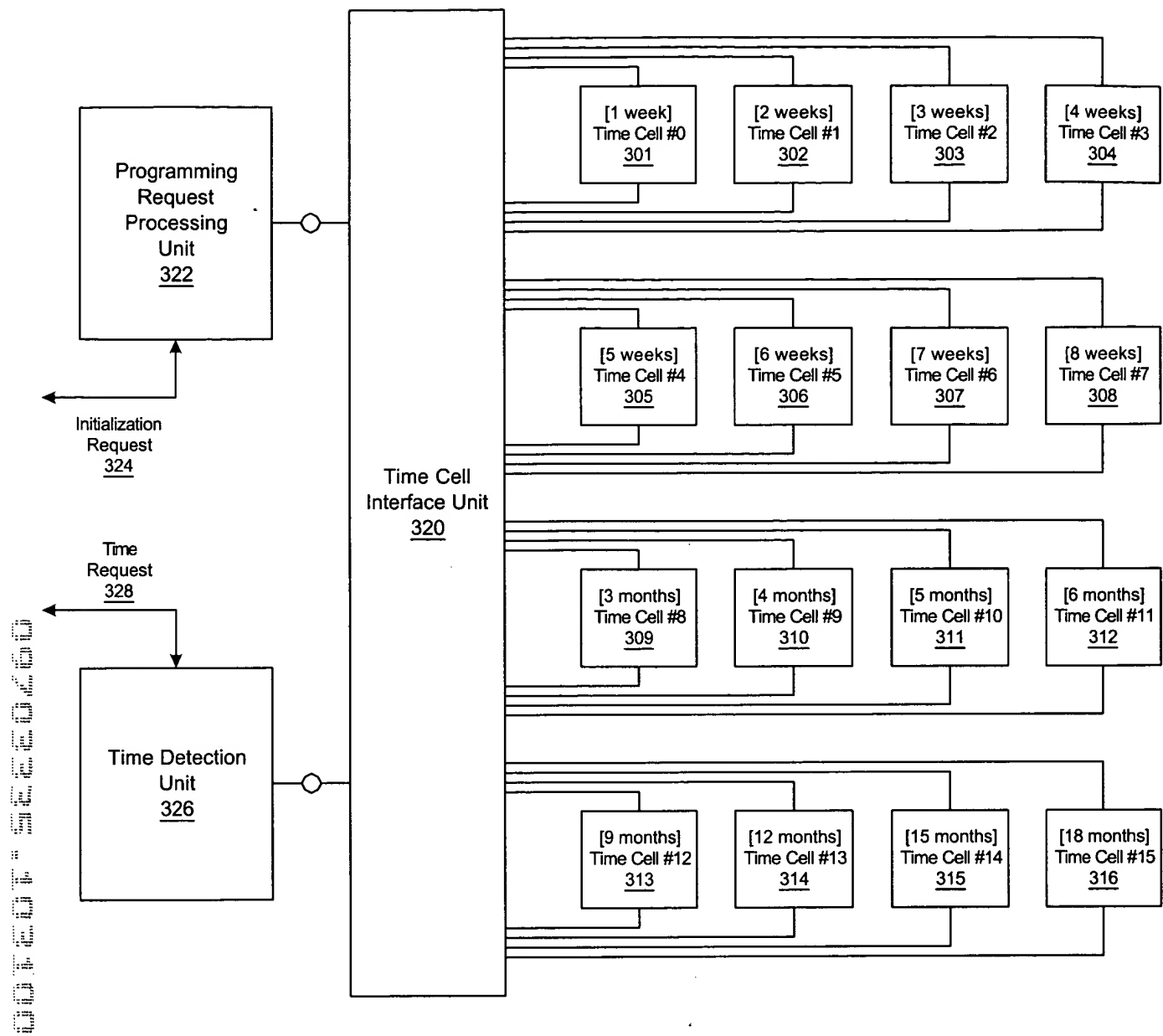


Figure 3A

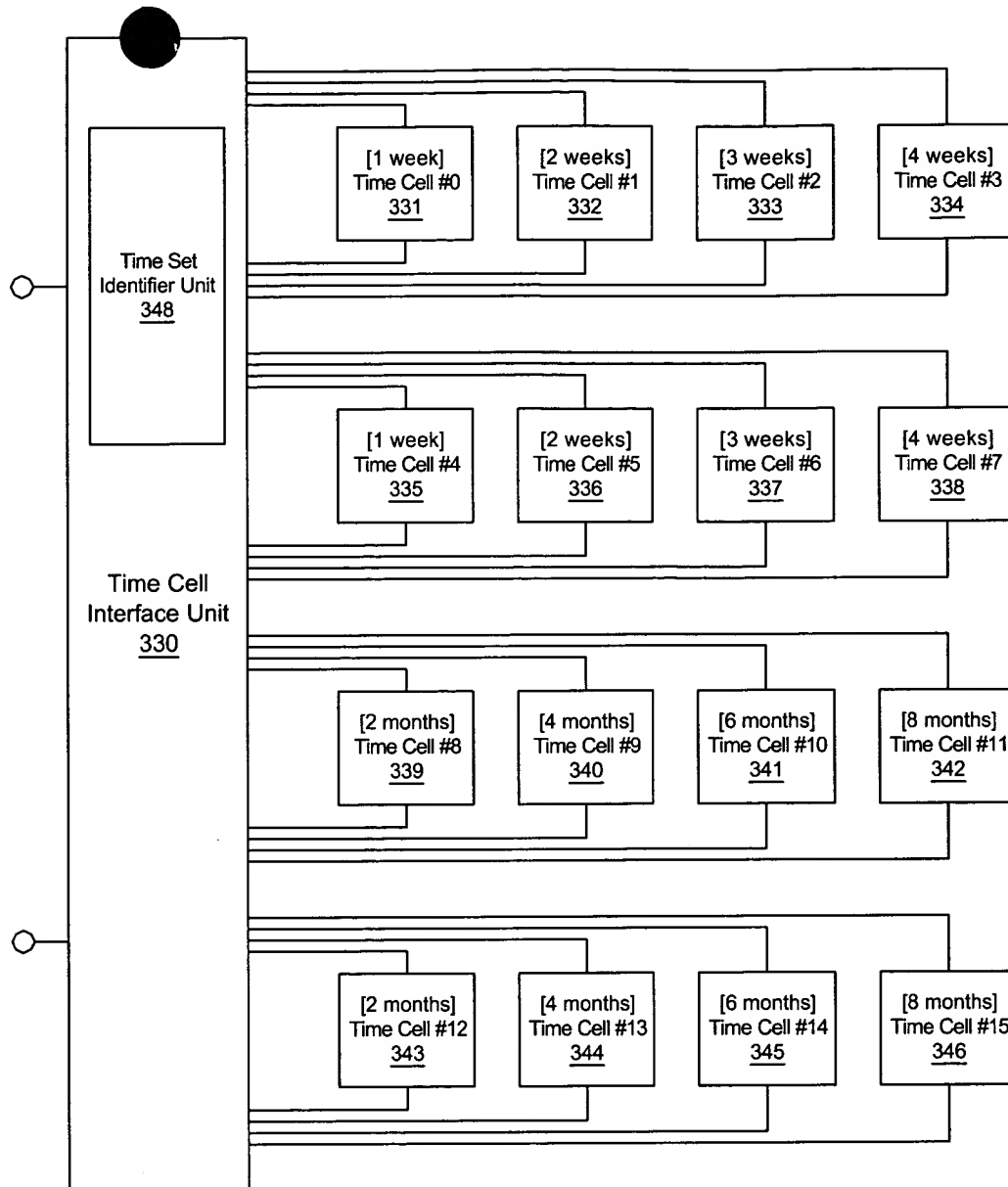


Figure 3B

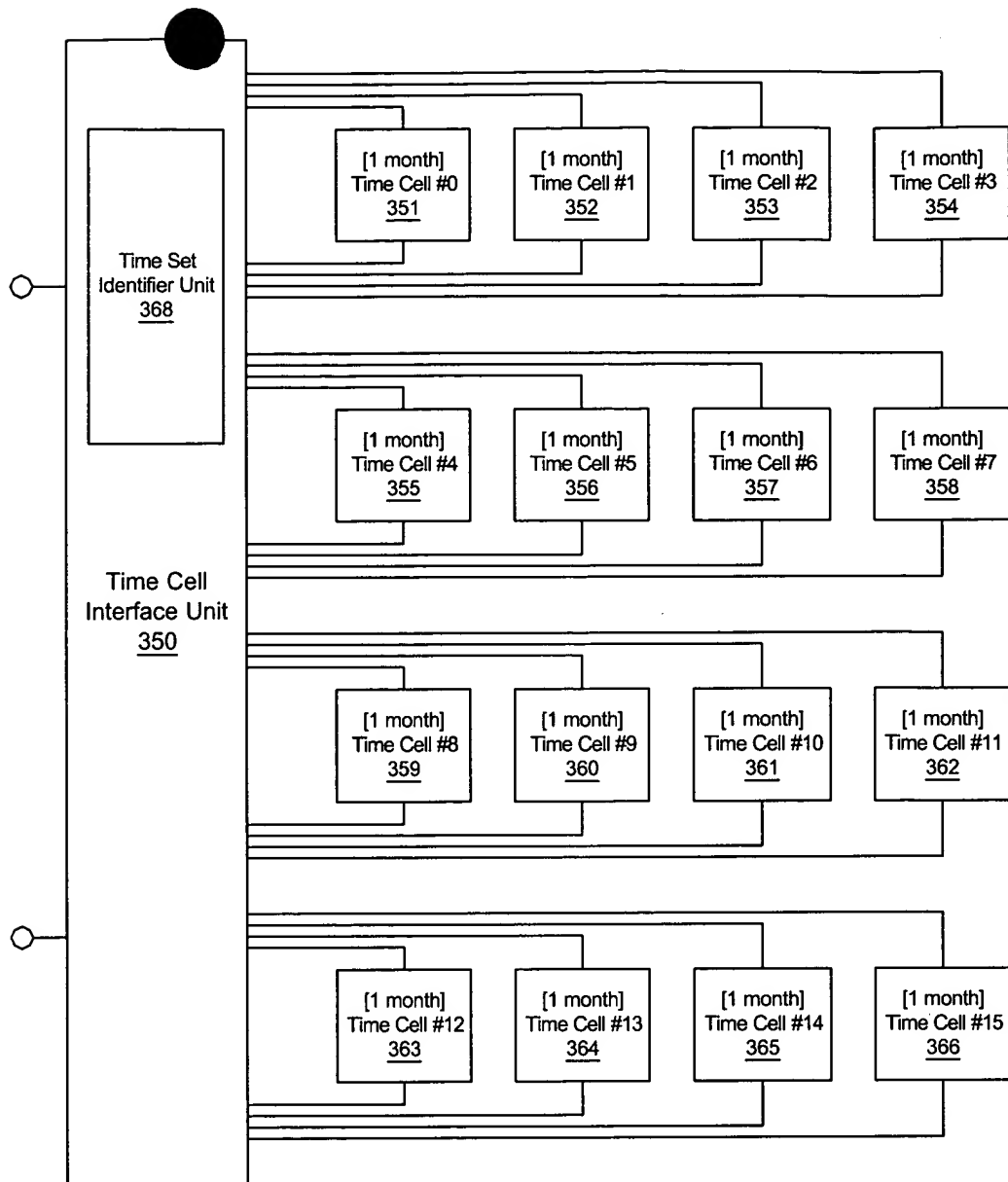
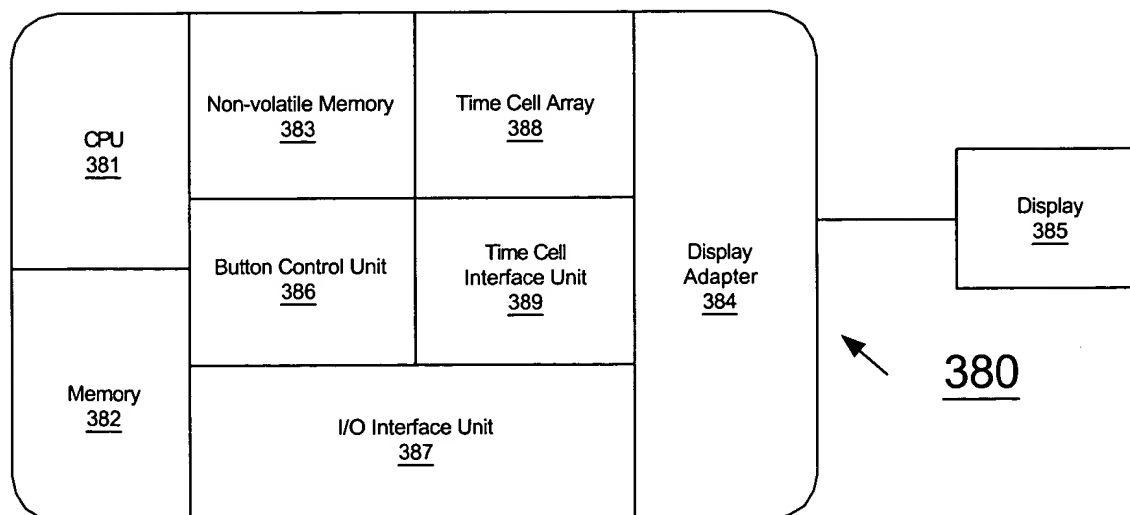
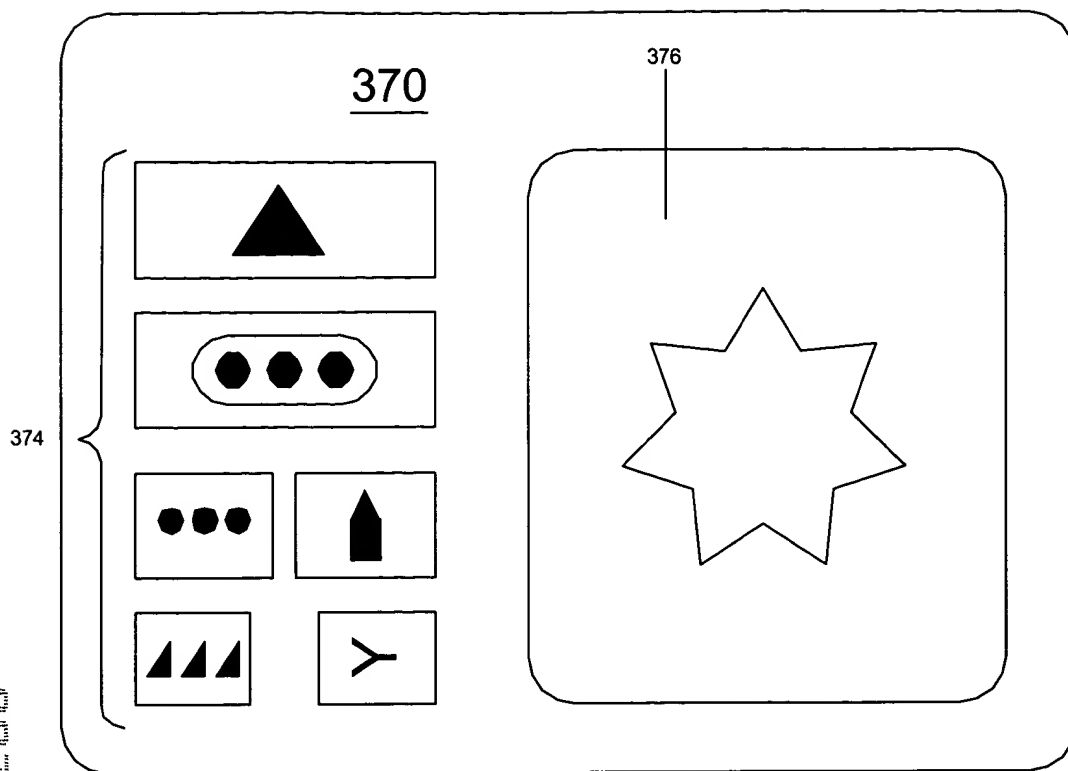
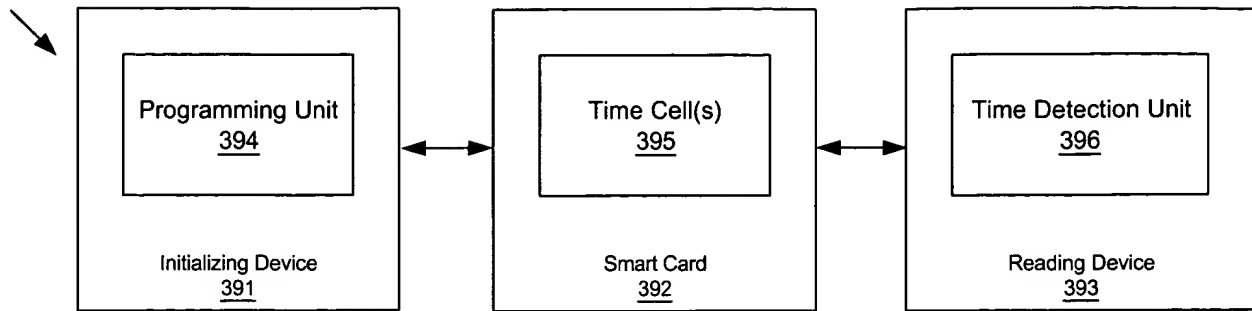


Figure 3C



390



### Figure 3F

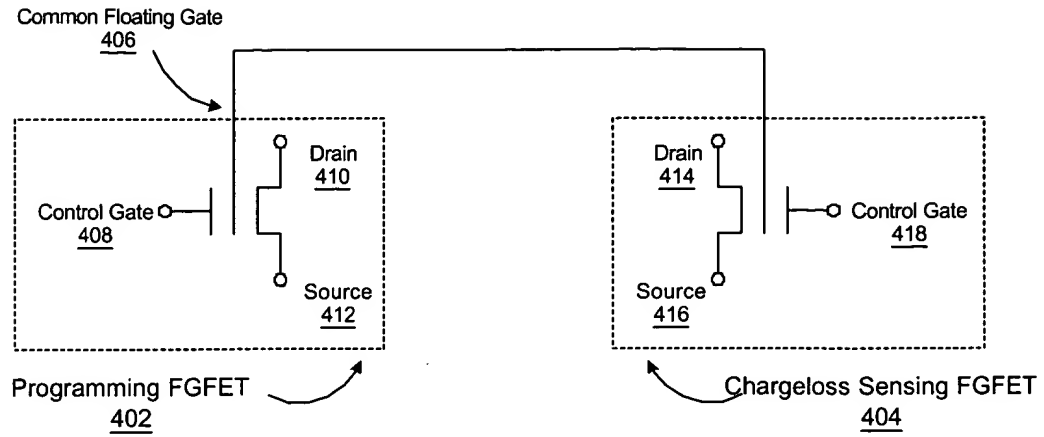


Figure 4A

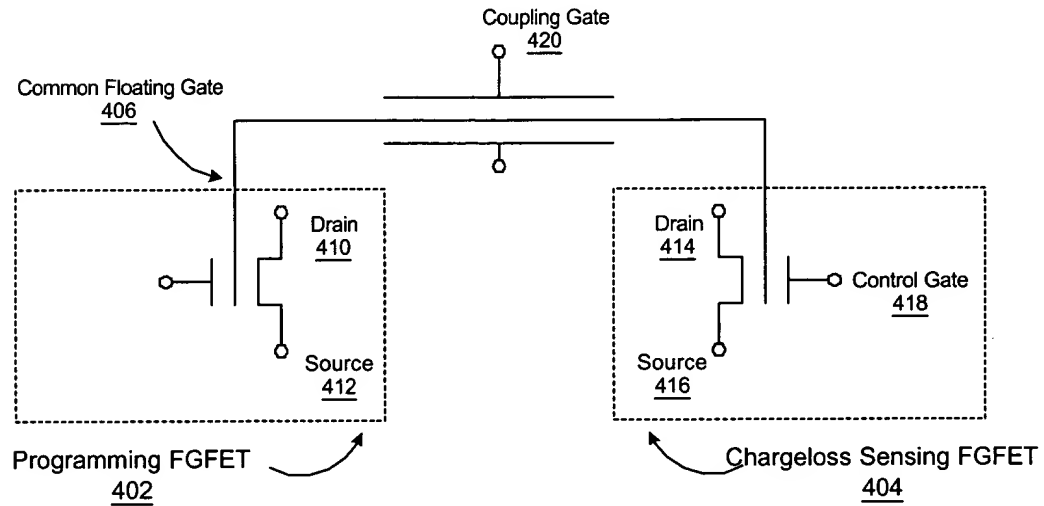


Figure 4B

# Voltages during programming operation

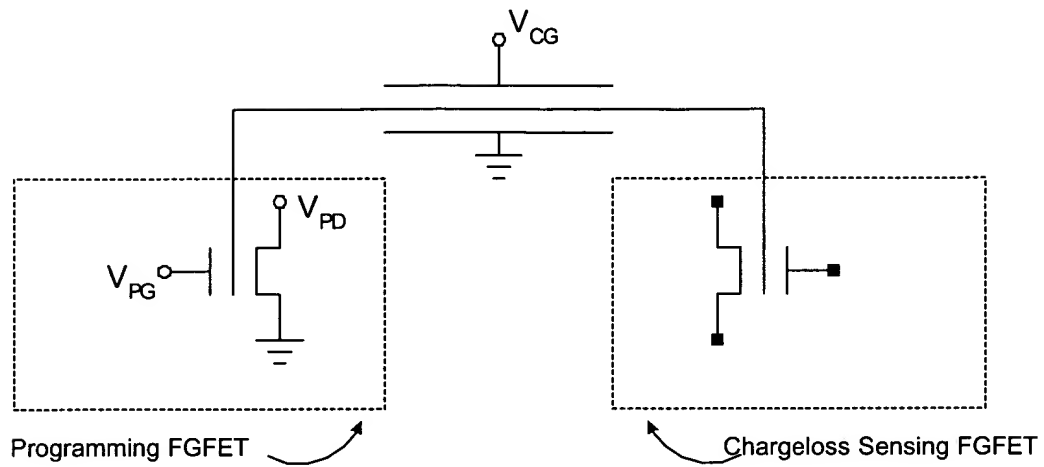


Figure 4C

# Voltages during sensing operation

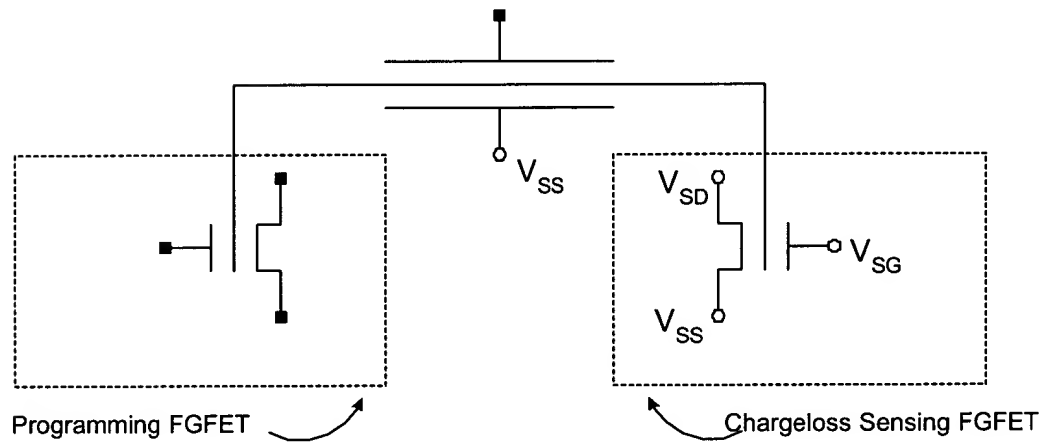


Figure 4D

007E07-3EE0260



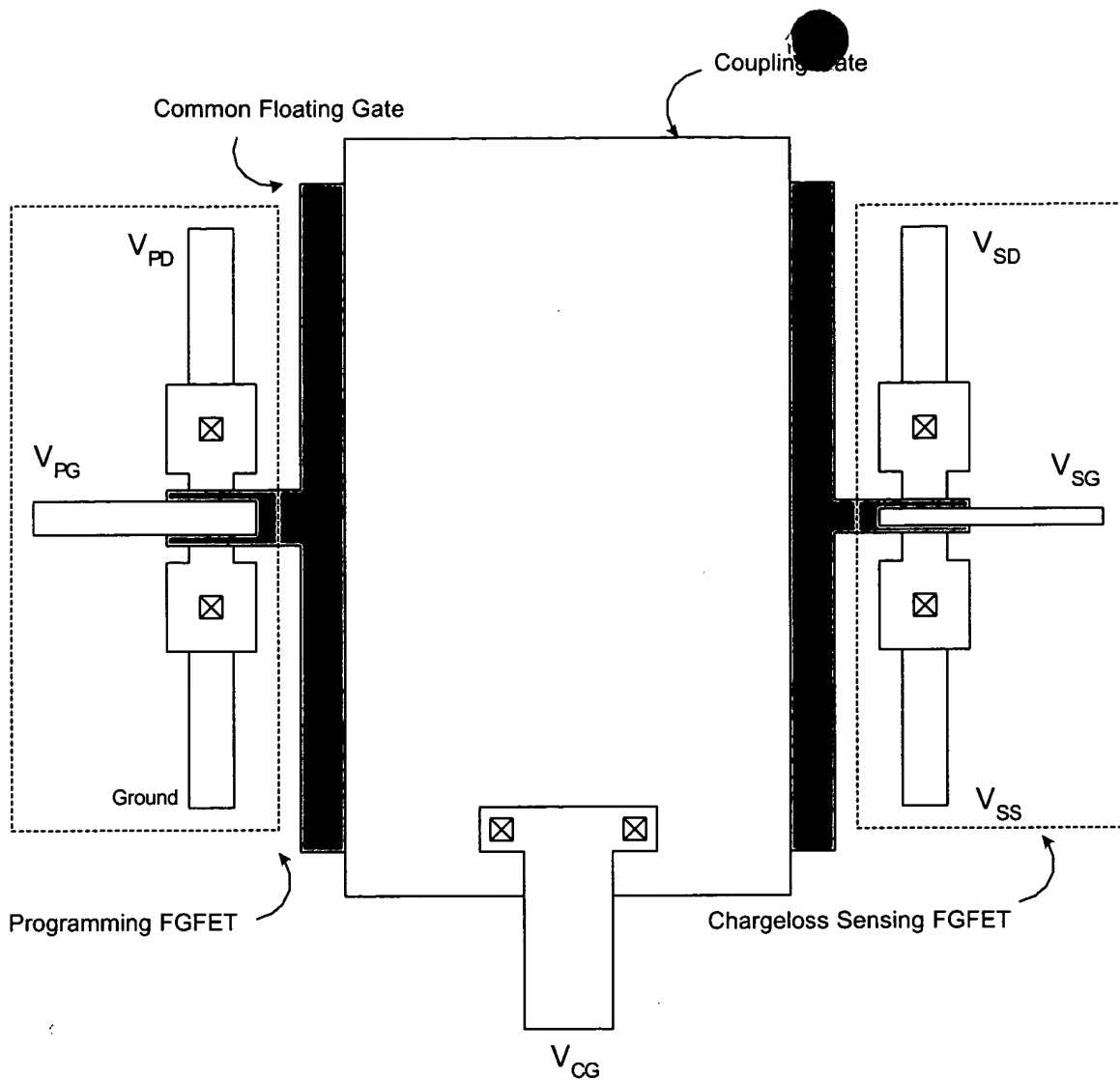


Figure 4E

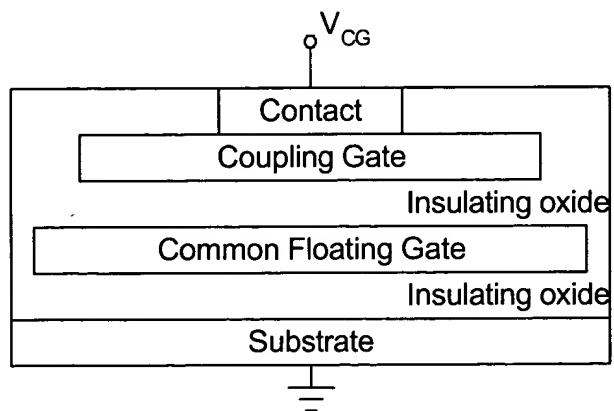


Figure 4F

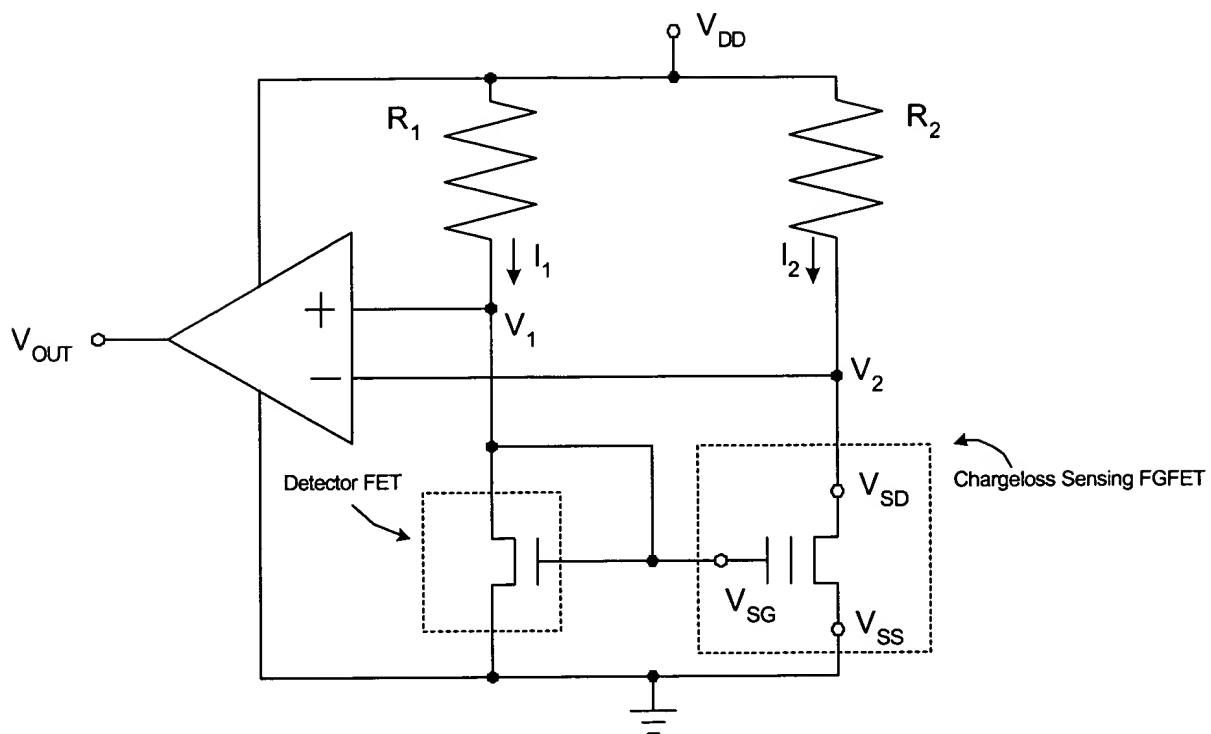


Figure 4G

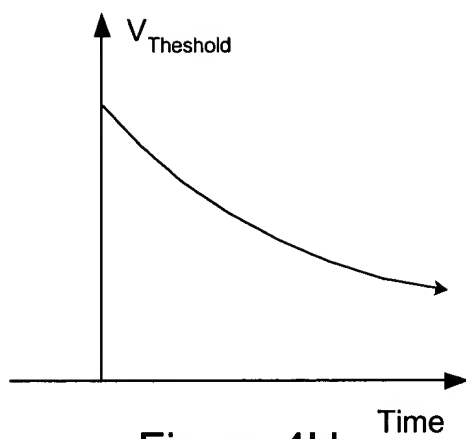


Figure 4H

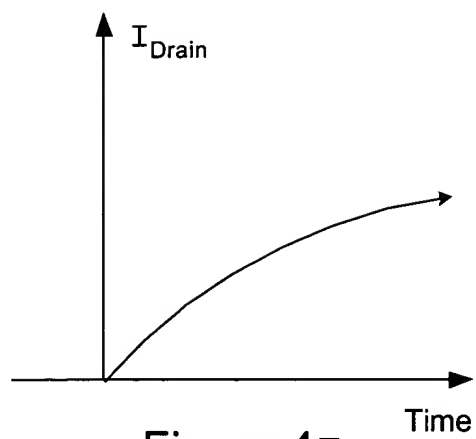


Figure 4I

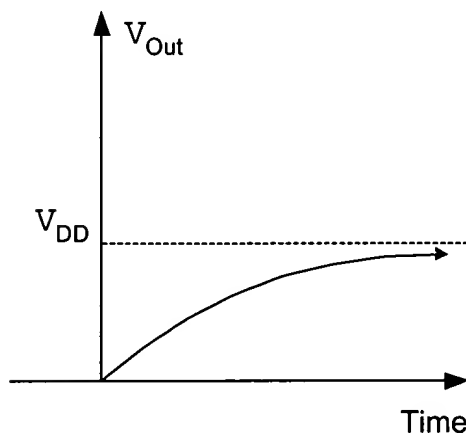


Figure 4J

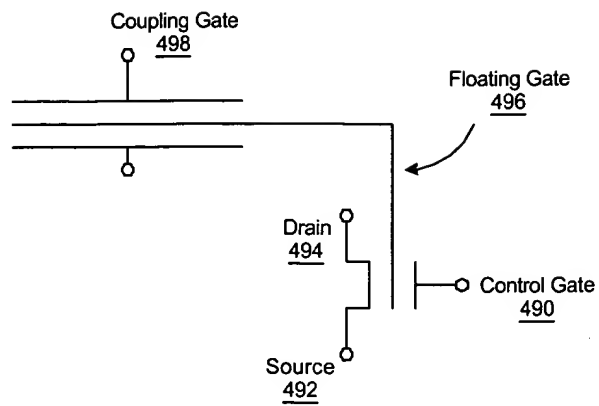


Figure 4M

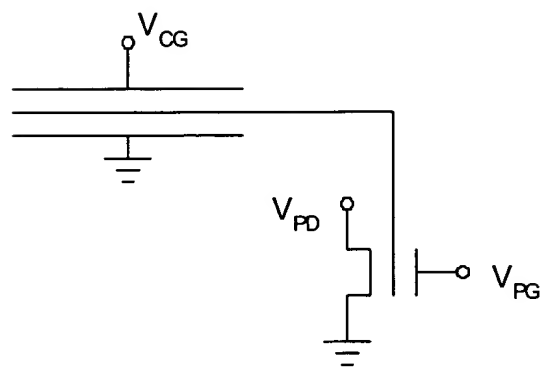


Figure 4N

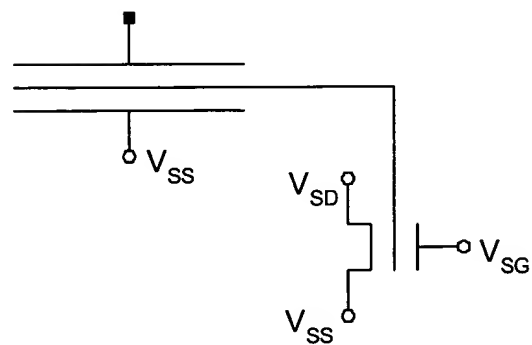


Figure 4O

450

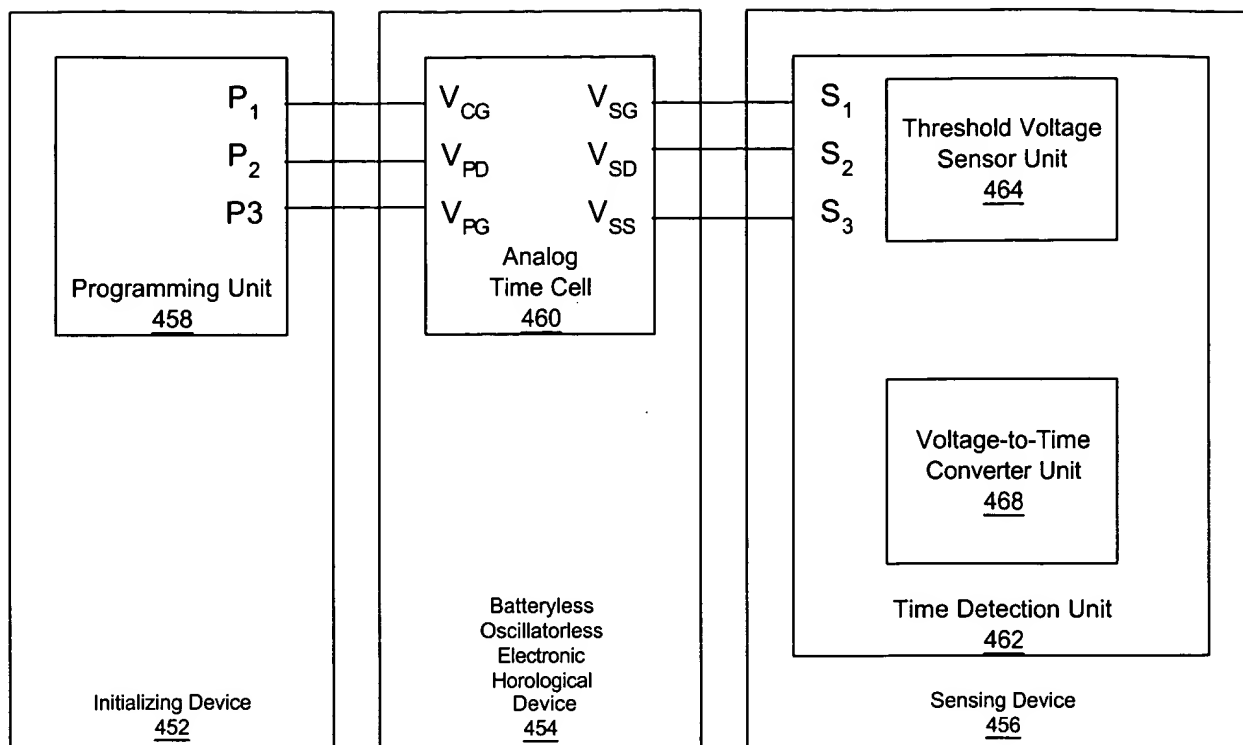


Figure 4K

470

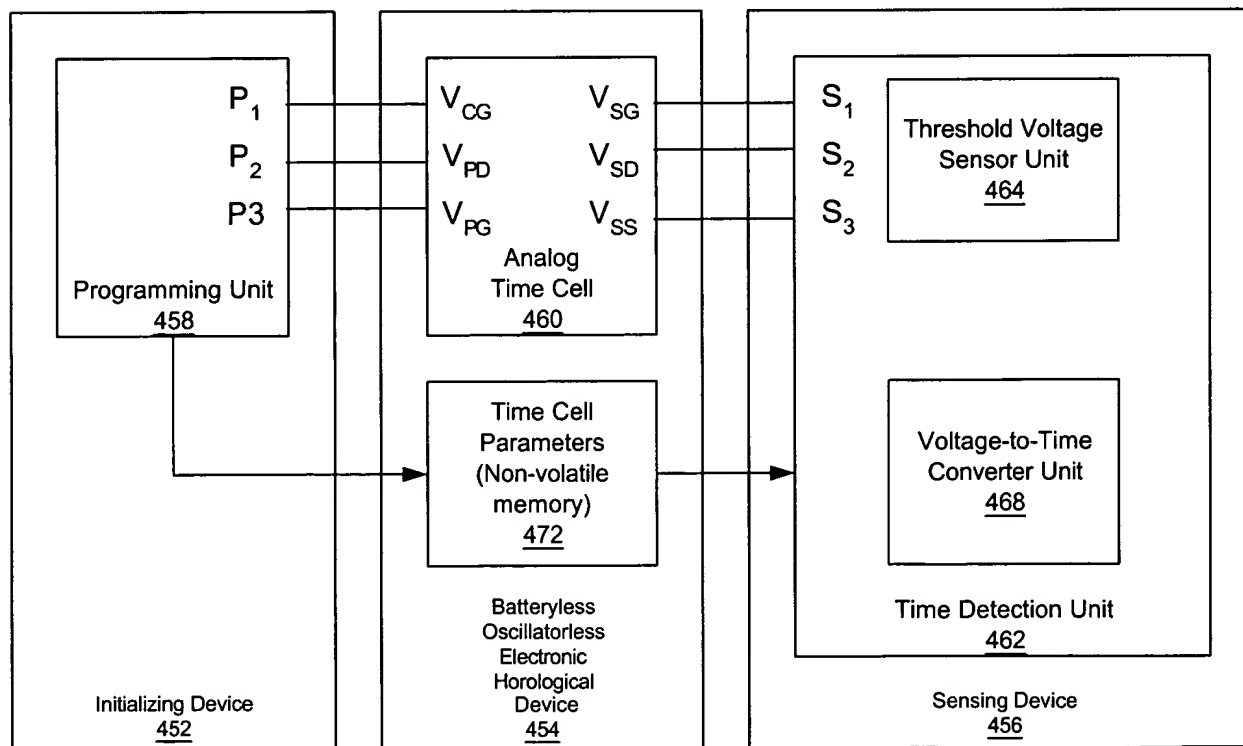


Figure 4L

001607 5830260

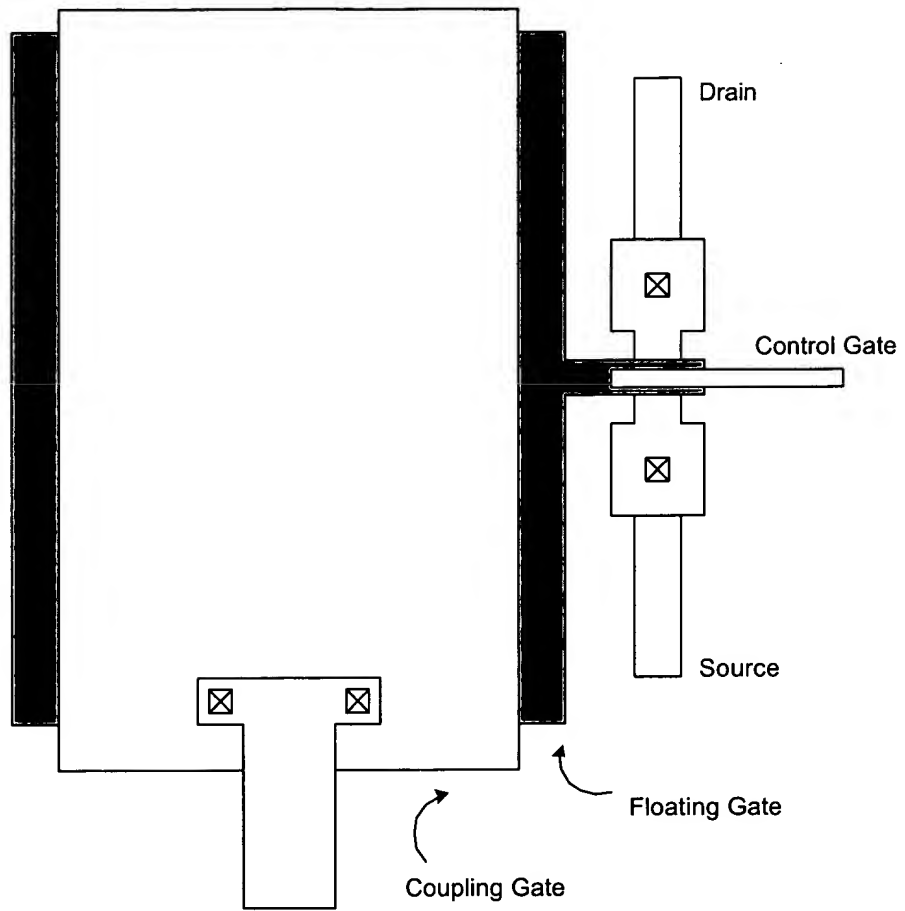


Figure 4P